

EV-Burner

The Solution to Ecologically and Economically Sound Power Plants

ABB Power Generation

ABB
ASEA BROWN BOVERI

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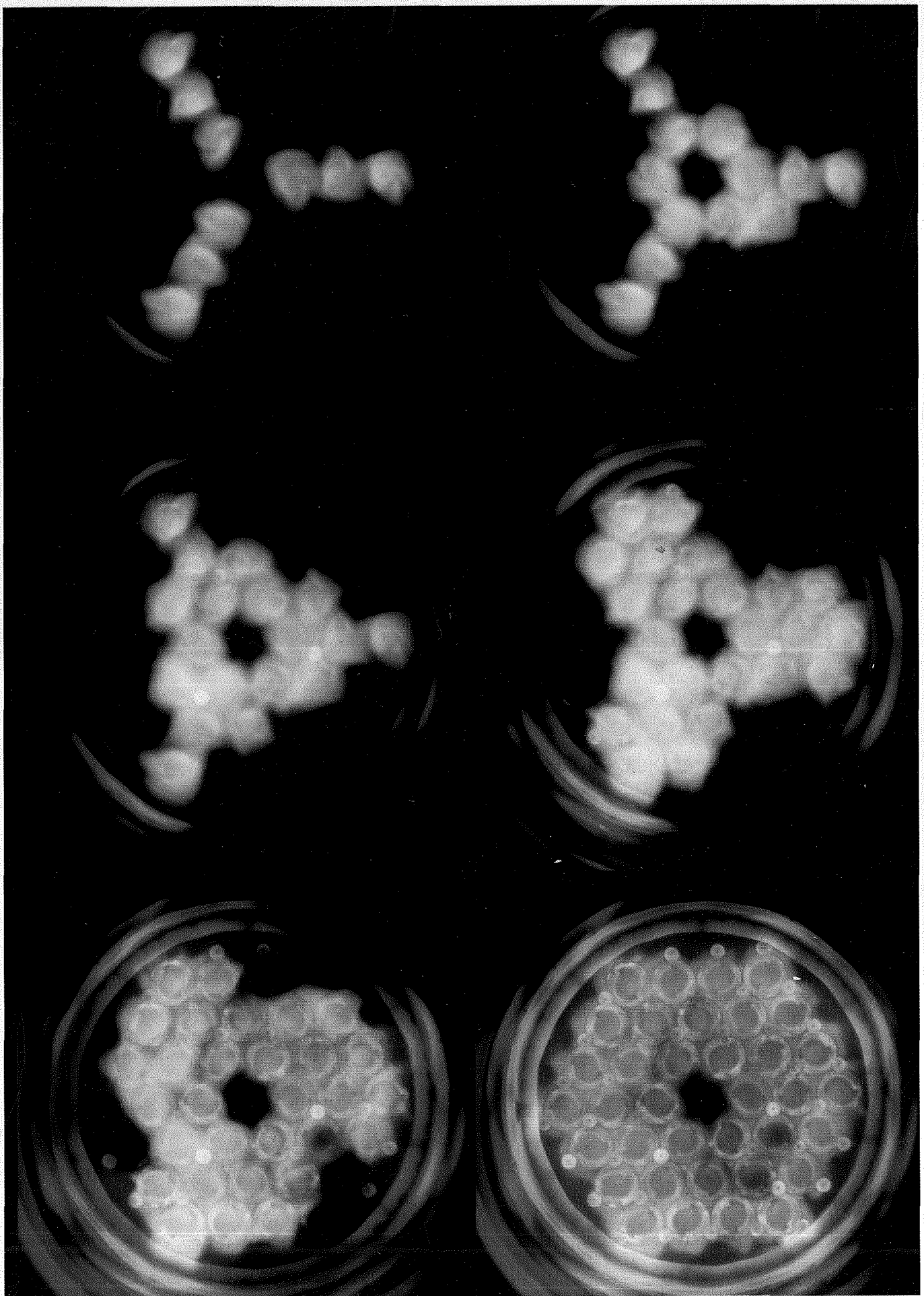


Fig. 1: Silo combustor with EV-burners: ignition to idling . . . part load . . . base load

Introduction

Present nitrogen oxide (NO_x) emission limits for gas turbines in Japan and the United States (notably California) can hardly be satisfied with commonly used NO_x abatement techniques. Although the 75 ppm, 15% oxygen EPA benchmark value is the prevailing US Federal standard, new projects now call for Best Available Control Technology (BACT) or specify an overall limit of ≤ 25 ppm. Before investing in new plant equipment, operators of power plants must seriously consider the public's interest in having ecologically-clean as well as economically-sound power plants.

Similar trends now emerge in Europe and with the increasing environmental awareness in the industrial nations it may not be long before a < 40 ppm limit is imposed throughout Western Europe.

Reducing harmful pollutants in the process of burning fossil fuel is a compromise: reducing carbon monoxide (CO) normally results in increased output of harmful NO_x , and vice versa. Whereas CO is very poisonous, NO_x can cause acid rain and, in combination with sunlight, increase ground-level ozone to unhealthy values. Carbon dioxide (CO_2) is another unwelcome pollutant; as some scientists believe, it can be a contributor to global warming. In addition, limited fossil fuel resources should be used as efficiently as possible — and this calls for an economical technology.

In the past, steam or water injection was the most widely used method for NO_x

reduction. The drawback of this method lies in its efficiency loss (when injecting water) and in its increased costs, arising from the injection water treatment. Selective Catalytic Reduction (SCR), a further NO_x reduction method, leads to even higher operating costs and lower efficiency.

ABB now presents an ecological as well as economical solution to the problem, by introducing a new dual fuel dry low- NO_x burner which is designed to meet NO_x emission limits down to 9 ppm on natural gas — without steam injection or SCR. A pragmatic approach combining theory, experimentation, and intuition resulted in a remarkably simple and efficient device: *the double cone burner*, also called *EV-burner*.

ABB's New EV-Burner Design

The EV-burner — the result of research started in 1987 — is the latest step in ABB's development program. Rather than just concentrating on ever lower NO_x levels, ABB has chosen a total solution that limits pollutants and at the same time increases energy efficiency. The "environmental" (EV) burner delivers NO_x levels lower than 15 ppm, a value considered unrealistic in dry combustion only a short time ago. When gas is

burned, ABB can guarantee 25 ppm dry, while 42 ppm can be achieved burning oil, with water injection. Years of research into new combustor technologies and extensive test programs have led to a system that also yields particularly low emission values for carbon monoxide (CO) and unburnt hydrocarbons (UHC).

ABB's new EV-burner is cleaner and more efficient than the company's conventional burners, while being reliable and safe due to its simple design.

Operating Principle

The EV-burner is a *dual fuel burner*, this means that it can be operated on gaseous fuel, on liquid fuel, or in dual fuel operation.

The burner is shaped like two half-cones (400 mm long, 150 mm in diameter) slightly offset sideways to form two inlet slots of constant width running the full length.

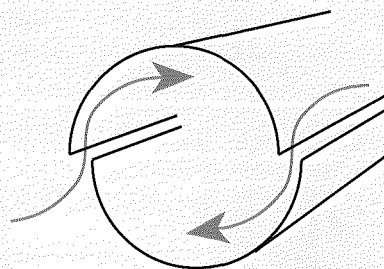


Fig. 3: Two half cones, forming two inlet slots

Combustion air enters the cone through these slots and gas is injected through a series of fine holes in their edges. With this arrangement fuel and air are intimately mixed.

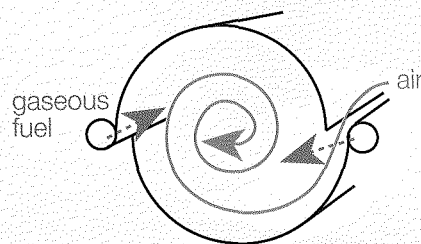


Fig. 4: Fuel and air are mixed at the inlet slots

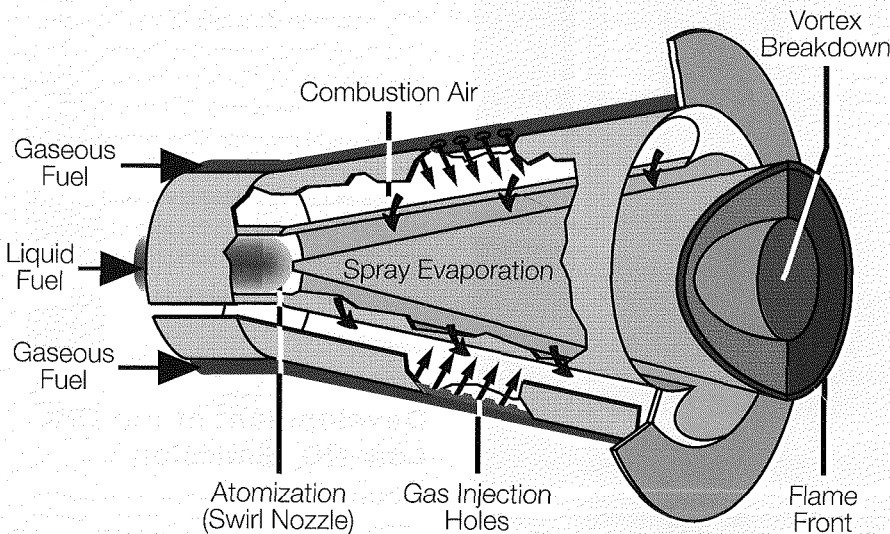


Fig. 2: Dual fuel double cone burner

The liquid fuels are sprayed into the cone through an atomizing nozzle. The combustion air enters the cone in the usual way, where it is mixed with the vaporized fuel. Water injection can also be applied.

The design of the EV-burner is based on the vortex breakdown principle:

A lean mixture leaves the cone and enters the flame. At the exit of the burner the vortex breaks down, forming a recirculation zone which stabilizes the flame in free space, keeping combustion temperatures and emissions low.

As there is no flameholder body exposed to ignitable mixtures, and no danger of any flashback damaging the burner, it is a very reliable and safe design.

Excess air is a feature of the EV-burner design, resulting in a flame temperature around 500 °C lower than in a conventional burner and in a very low NO_x level.

Applications

In the combustor there is no other burning mode than premix combustion. A group of burners act as a pilot system for all burners.

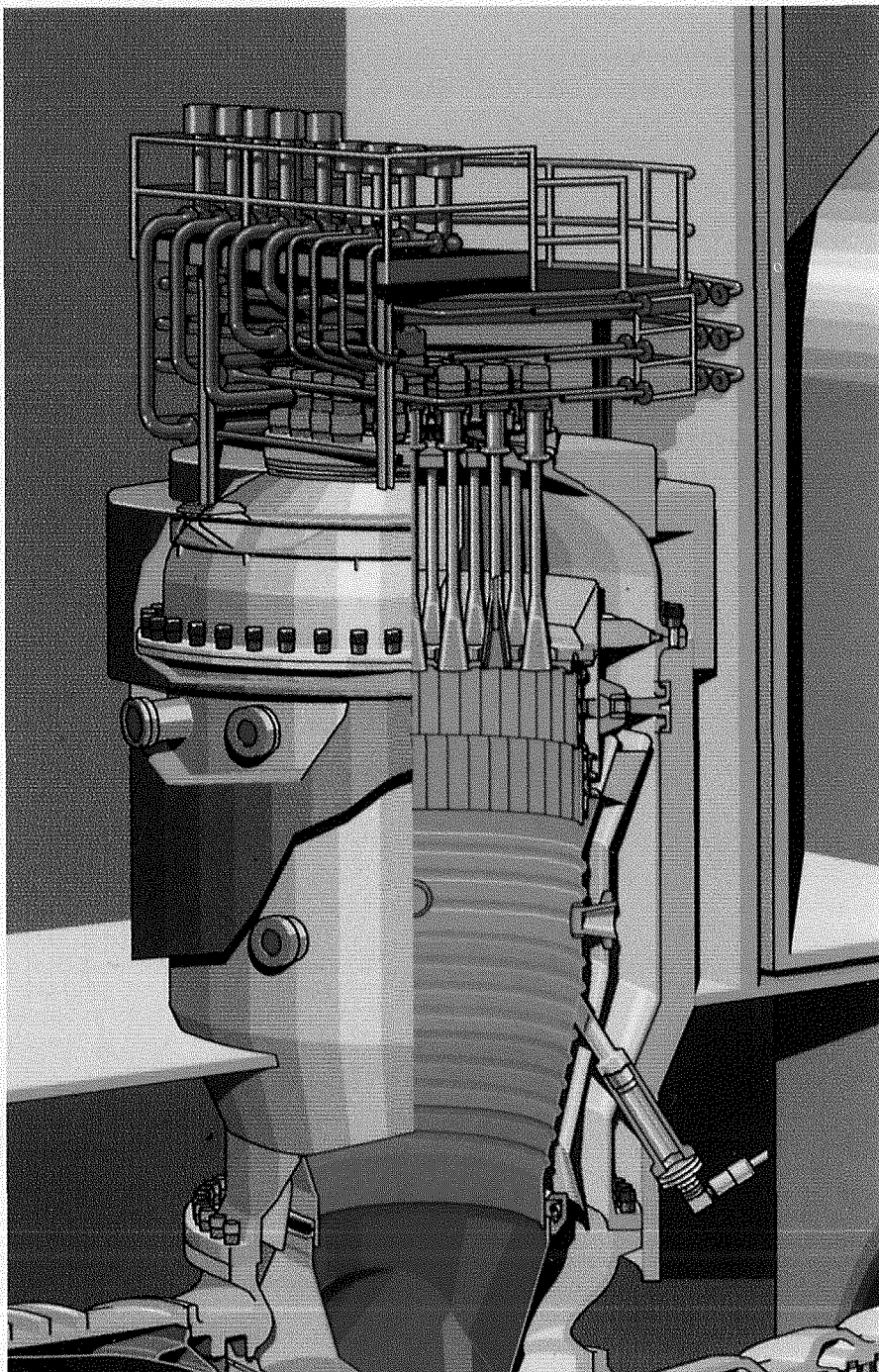
The EV-burner is suited to both *annular combustion chambers* and to standard *silo combustors* and it can be fitted to all of the company's gas turbine models. Existing units working with ABB's conventional burners can be retrofitted with EV-burners.

EV silo combustors are equipped with 19–54 burners (number of burners depending on gas turbine type) and achieve NO_x emission values below 25 ppm with natural gas.

The EV-burner can be fitted to the annular combustion system of the 24 MW GT10 turbine.

Another application is with ABB's latest heavy-duty gas turbine of the proven GT13 family; the combustion chamber on the GT13E2 is of the single annular type, with 72 burners arranged symmetrically around the annulus in four rows. With natural gas, the NO_x value is well below 25 ppm.

Fig. 5: EV-silo combustor



Development History

As the formation of nitrogen oxides in the process depends both on the firing temperature and the residence time of the fuel/air mixture in the combustion zone, conventional burners produce high amounts of NO_x. By injecting water directly into the flame, it is possible to lower the temperature and thus reduce NO_x emission to levels of 25–75 ppm. This traditional method of lowering NO_x produced in gas turbines is used widely throughout the world. But this "wet" combustion process also considerably lowers energy efficiency, increases the output of CO due to incomplete combustion, uses large amounts of water, and causes higher maintenance costs.

Development of the Dry Low-NO_x Emission Techniques

ABB's approach to this problem was the development of the dry low-NO_x burner. The design and development history leads from ABB's conventional diffusion

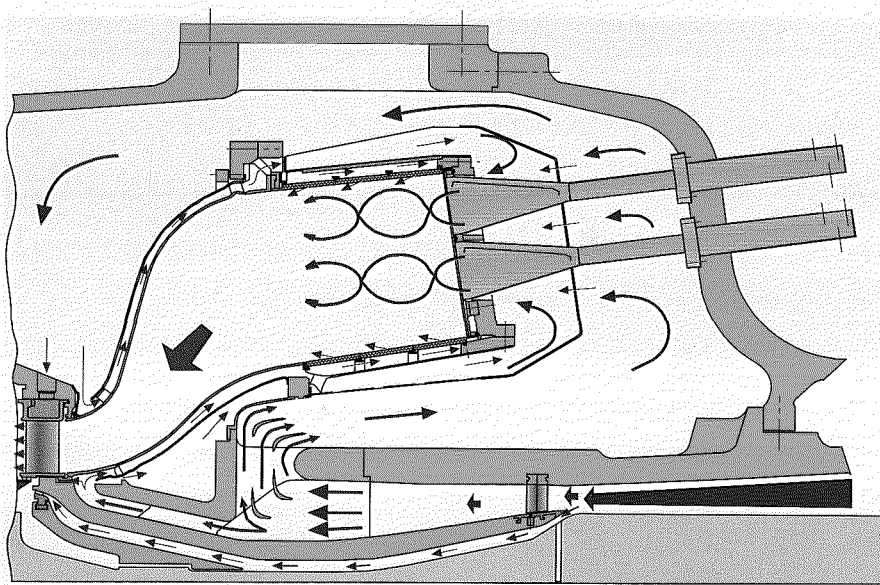


Fig. 6: Annular combustor of the GT13E2

burner to the advanced EV-burner, covering various evolution phases — starting with the *first-generation lean premix burner*:

Its concept is based on the simple principle of premixing air and fuel, with the maximum amount of excess air, before combustion. One burner consists of a premixing section, a separate combustion zone and a solid flame holder.

The temperature of the flame is determined by the homogeneity of the air/fuel mixture and the amount of excess air in

the combustion. About twice the theoretical amount of air required for combustion is used — thus giving the method its name “lean premix”. The flame temperature is at least 500 °C lower than in the company’s regular diffusion burner design and therefore NO_x emission is reduced to 40–60 ppm.

First commercial operation of these dry low-NO_x burners occurred in 1984 on a Type 13 gas turbine, when the turbine’s diffusion burner was replaced by a bundle of lean premix burners.

The first-generation lean premix burners need careful monitoring and often use diffusion or pilot flames against combustion instabilities.

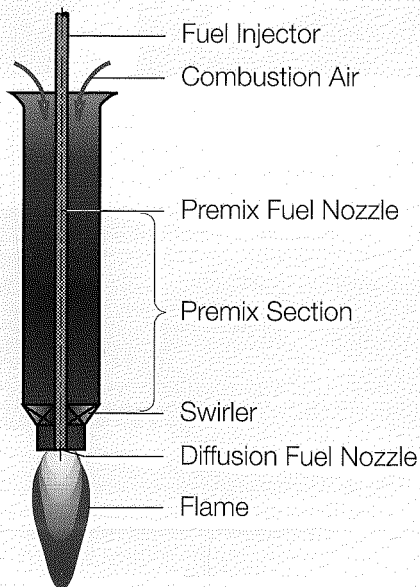


Fig. 7: First-generation premix burner

Invention of the EV-Burner

Building on the experience gained from its first-generation lean premix burner, in 1987 ABB launched an intensive re-research program to reduce NO_x levels to 25 ppm or less, while retaining optimum energy efficiency.

This program led to the *second-generation lean premix burner*, the EV-burner, which features a completely new construction: a cone with tangential air inlets.

The two key features of the new burner are the exceptionally simple design and the fact that the premixing chambers have disappeared.

Due to the flame stabilization in free space, premixing chamber and combustion chamber can be combined. The result is a safe and simple device which reaches the best possible emission limits, well below present and planned limits in Europe.

Tests

ABB has conducted fundamental research related to premixed flames since 1984. Since its development, the ABB dry low-NO_x combustor has logged more than 120,000 hours of operational experience. The research concept leading to the invention of the EV-burner included the following evolution phases:

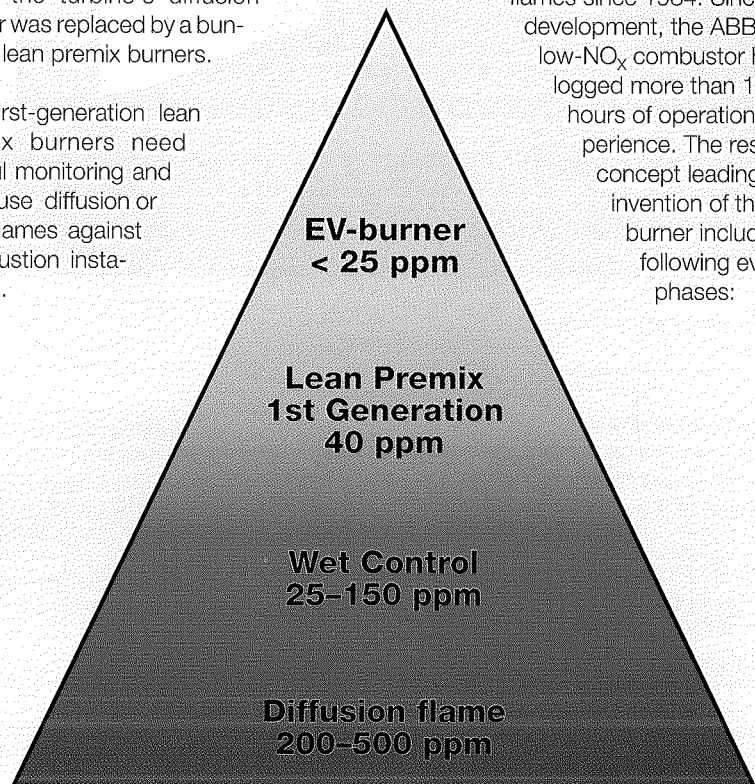


Fig. 8: Development of the dry low-NO_x burner



Fig. 9: Assembly of the EV-burner

1. Basic phenomena were investigated in the research-center in Baden, Switzerland. These studies led to the invention of the double cone burner.
2. Full scale investigations in the combustion laboratory. Extensive segment tests under various operating conditions have been carried out in ABB's test facilities on a test combustor equipped with EV-burners.
3. Systematic and extensive high pressure tests with a single burner.

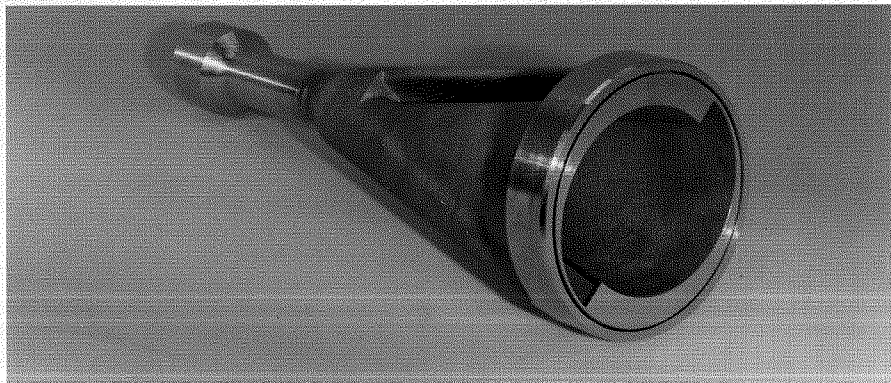


Fig. 10: The EV-burner, designed to provide low NO_x emission and high fuel efficiency

4. Test runs on a model of a GT11N silo combustor.
5. Field measurements: a GT11N was retrofitted with a silo combustor equipped with EV-burners.
6. High pressure tests with a combustor segment.
7. Single annular combustors integrated in a GT10 and GT13E2.

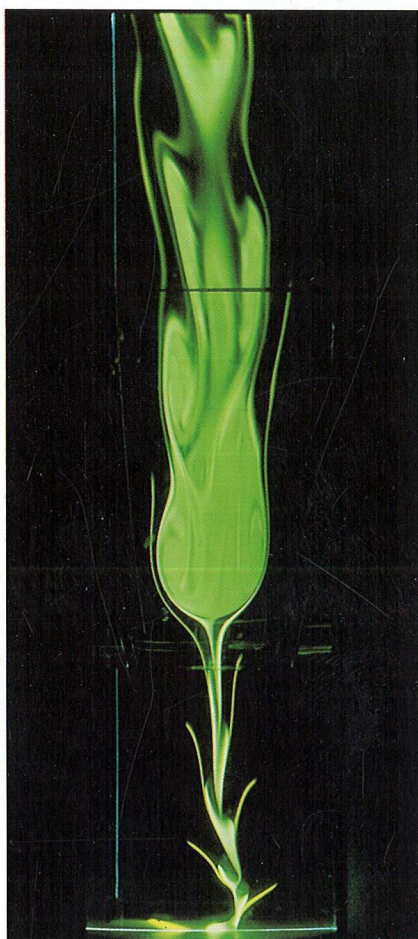


Fig. 11: Simulation of the vortex breakdown

Convincing in Commercial Operation

To achieve a breakthrough in burner technology is one thing, but the company also felt that any system development would have to prove its reliability and consistent performance in actual, extended operation. ABB's second gen-

eration of advanced low-emission burners was subjected to an on-site field test at the Midland power plant in the U.S.A.: the results were so convincing that the new burner could take up commercial operation in record time in spring 1991, blurring the line between test and commercial performance. Since then, several other gas turbines have been successfully retrofitted and additional new units have been brought into operation with EV-burners.

A Well-proven Advanced Technology . . .

Through many field tests ABB has demonstrated the success of this low emission technology, which is based on the company's many years of experience and research in the field. Systematic step by step developments since 1978 have led to the world's best dry low- NO_x technology:

- World's first dry low- NO_x combustor from ABB operates commercially since 1984.
- ABB has more than 120,000 hours of operating experience concerning lean premix systems in different installations.

. . .With Many Benefits:

- Lowest achievable NO_x , CO/UHC emissions.
- Simple design, reliable and safe operation.
- Suitable for silo combustors as well as for annular combustion chambers.
- Good flame stability due to sophisticated but simple aerodynamic design.
- Designed for single or dual fuel operation with a broad range of liquid and gaseous fuels.
- Water injection is possible for wet NO_x control.
- No vibration, no combustion instability.

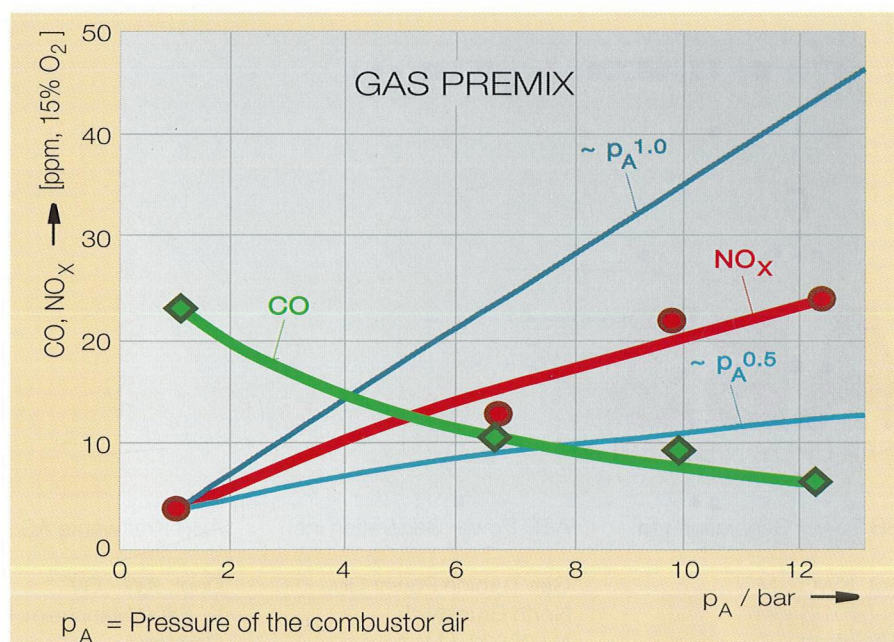


Fig. 12: Emissions measured for a given fuel to air ratio

ABB is one of the world's most progressive industrial groups with 225,000 employees and total sales of US \$30 billion.

We have a unique commitment to electrical engineering: generating power, getting it to where it is needed, and using it efficiently in industry, transportation, environmental systems and other key sectors.

An outstanding example of ABB's innovative power is the new EV-burner, which makes today's gas turbines the environmentally compatible power station option for the future. This advanced combustion technology is now available for the whole range of ABB gas turbines.

A convincingly simple and wear-resistant design that meets challenging environmental needs . . . economically. Featuring very low NO_x and CO emissions, exceptional operating flexibility and reliability.

Continuous research and product development, modern manufacturing facilities, rigorous quality control, world-wide financing, total project management, and an established service network, guarantee optimum round-the-clock performance in over 150 countries.

Above all, we listen . . . and we're flexible. Whatever and wherever your needs are, ABB is the reliable route to clean, cost-efficient gas turbine power.



ABB Power Generation Ltd.

Dept. KWG2-M
CH-5401 Baden
Switzerland
Phone +41 56 / 75 72 17
Fax +41 56 / 21 26 48

ABB Power Generation Inc.

Gas Turbine Power Div.
North Brunswick
NJ 08902, U.S.A.
Phone +1 908 / 932 6091
Fax +1 908 / 932 6194

ABB Kraftwerke AG

Dept. KW / GV
W-6800 Mannheim 1
Germany
Phone +49 621 / 381 64 74
Fax +49 621 / 381 62 44

ABB STAL AB

Gas Turbine Div.
S-612 20 Finspong
Sweden
Phone +46 122 / 8 19 28
Fax +46 122 / 1 97 00